Physics Overview

SoLID Director's Review Feb 23-24, 2015

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Overview of SoLID

Solenoidal **L**arge **I**ntensity **D**evice

- **Full exploitation of JLab 12 GeV Upgrade**

A **Large Acceptance** Detector **AND** Can Handle **High Luminosity** (10^{37}-10^{39})

Take advantage of latest development in detectors and data acquisitions

- Reach ultimate precision for SIDIS (TMDs), providing three-dimensional imaging of nucleon in momentum space
- PVDIS in high-*x* region, providing sensitivity to new physics at 10-20 TeV
- Threshold J/ψ, probing strong color field in the nucleon, trace anomaly

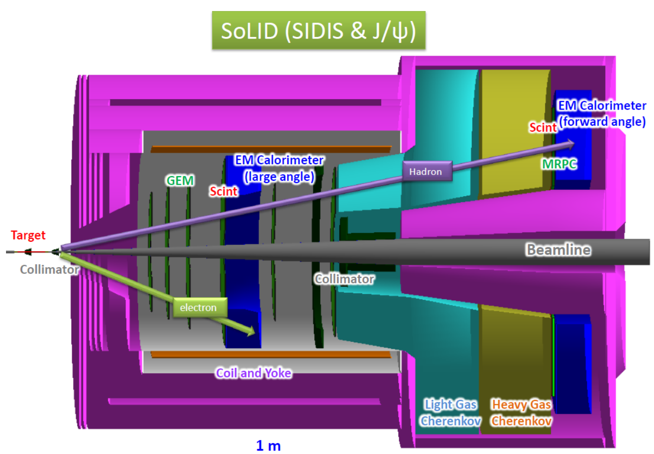
- **5 highly rated experiments approved**

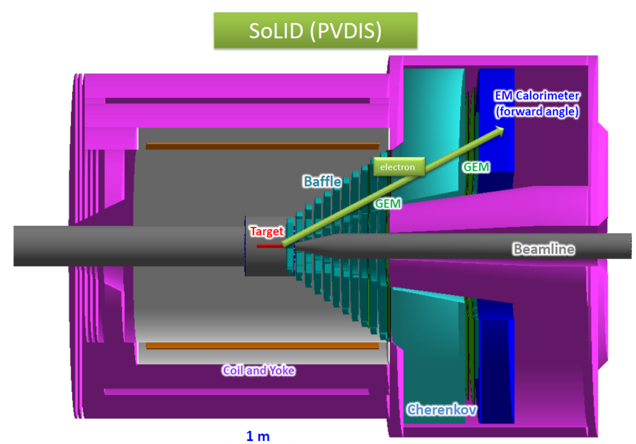
  Three SIDIS experiments, one PVDIS, one J/ψ production

  Bonus: di-hadron, Inclusive-SSA, and much more …

- **Strong collaboration** (200+ collaborators from 50+ institutes, 11 countries)

  Significant international contributions and strong theoretical support

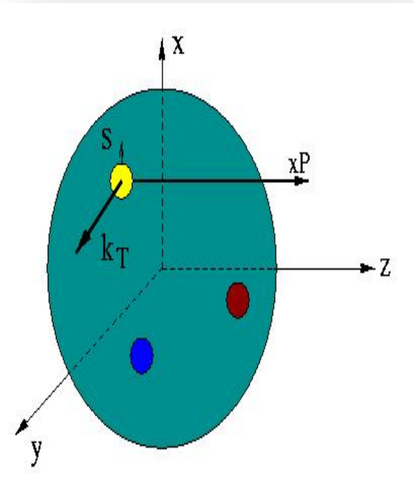




Unified View of Nucleon Structure

$W_p^u(x, k_T, \boldsymbol{r_T})$ Wigner distributions

5D Dist.

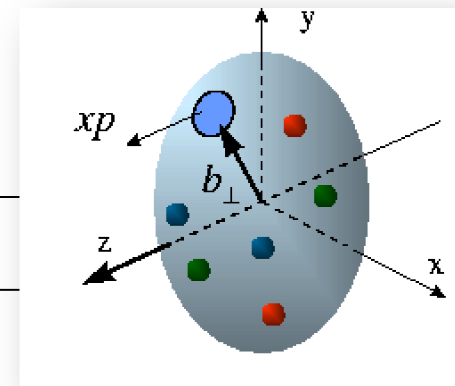


$d^2\boldsymbol{r_T}$

d^2k_T

TMD PDFs
$f_1^u(x,k_T)$, ..
$h_1^u(x,k_T)$

GPDs/IPDs

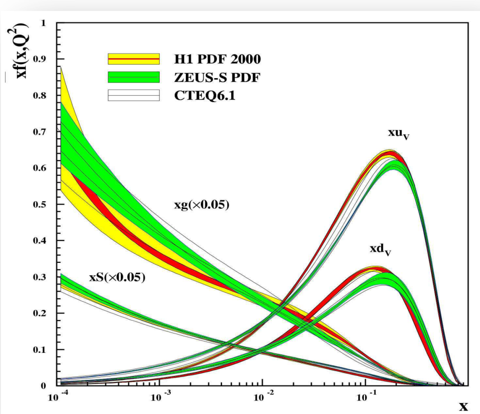


3D imaging

d^2k_T

d^2r_T

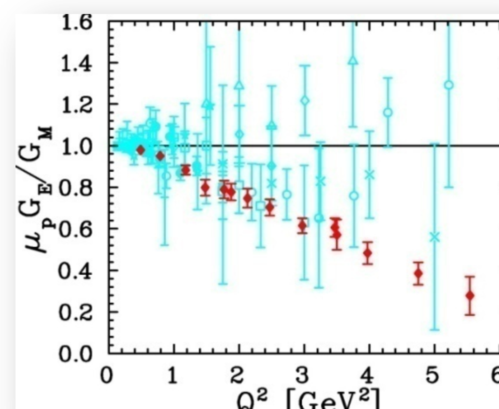
dx &
Fourier Transformation



PDFs
$f_1^u(x)$, ..
$h_1^u(x)$

1D

Form
Factors
$G_E(Q^2)$,
$G_M(Q^2)$

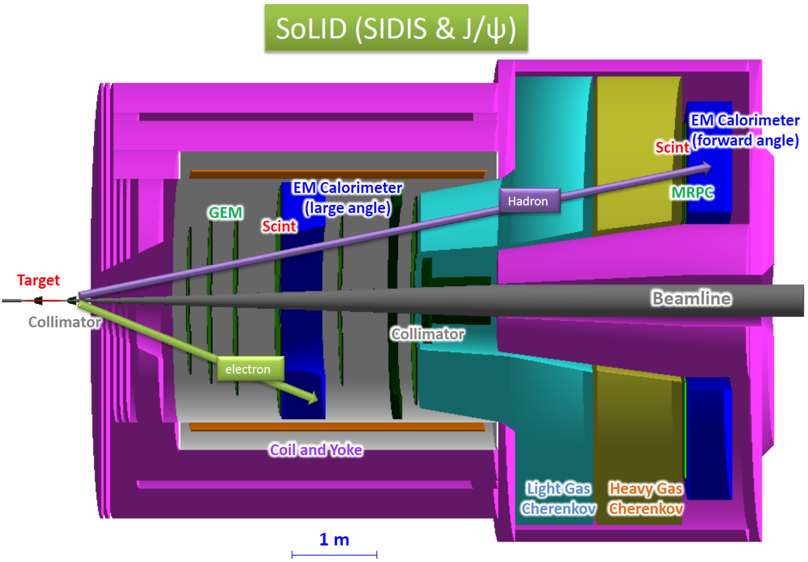


Leading Twist TMDS

Nucleon Spin
Quark Spin

		Quark polarization		
		Un-Polarized	Longitudinally Polarized	Transversely Polarized
Nucleon Polarization	U	$f_1 =$		$h_1^{\perp} =$ − **Boer-Mulder**
	L		$g_1 =$ − **Helicity**	$h_{1L}^{\perp} =$ −
	T	$f_{1T}^{\perp} =$ − **Sivers**	$g_{1T}^{\perp} =$ −	$h_{1T} =$ − **Transversity** $h_{1T}^{\perp} =$ − **Pretzelosity**

SoLID-Spin: SIDIS on ^{3}He/Proton @ 11 GeV

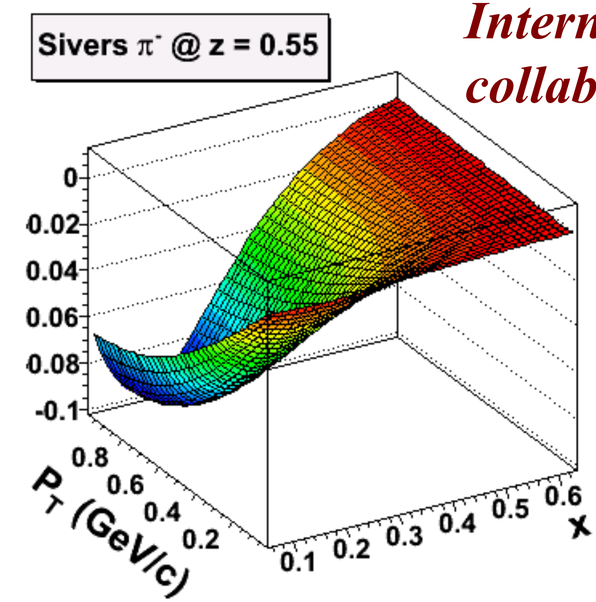


E12-10-006: Single Spin Asymmetry on Transverse ^{3}He @ 90 days, **rating A**

E12-11-007: Single and Double Spin Asymmetry on ^{3}He @ 35 days, **rating A**

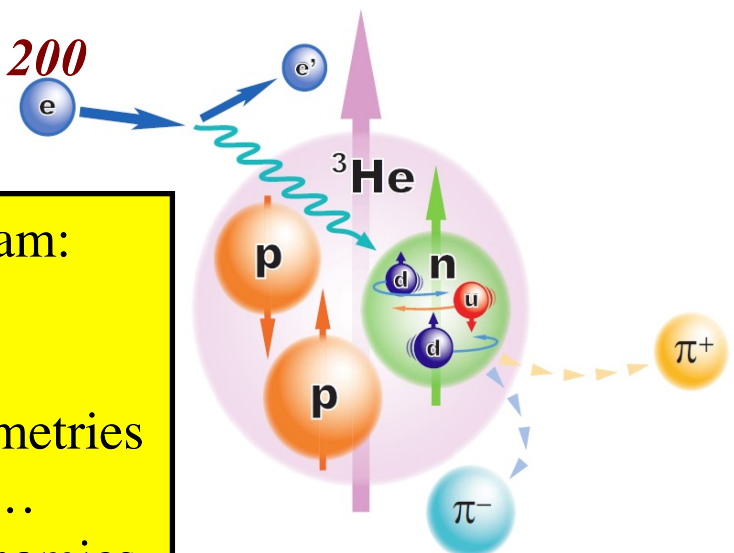
E12-11-108: Single and Double Spin Asymmetries on Transverse Proton @120 days, **rating A**

Two ``bonus" experiments approved



International collaboration with 200 collaborators from 11 countries

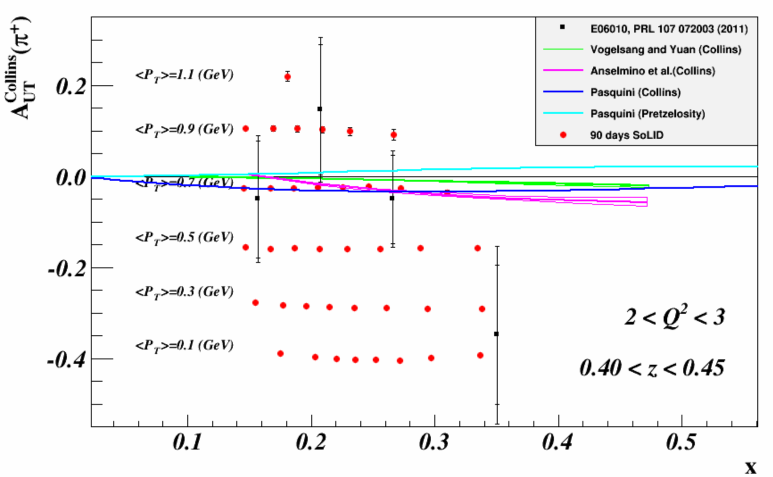
Key of SoLID-Spin program:
Large Acceptance
+ High Luminosity
→ **4-D** mapping of asymmetries
→ Tensor charge, TMDs …
→Lattice QCD, QCD Dynamics, Models.



Transversity and Tensor Charge

- Collins Asymmetries ~ Transversity (x) Collin Function
- **Transversity**: chiral-odd, not couple to gluons, **valence behavior**, largely unknown
- **Tensor charge (0th moment of transversity): fundamental property**
  Lattice QCD, Bound-State QCD (Dyson-Schwinger) , Light-cone Quark Models, …
- Global model fits to experiments (SIDIS and e+e-)
- SoLID with **trans polarized n & p** → determination of tensor charges for **d & u**

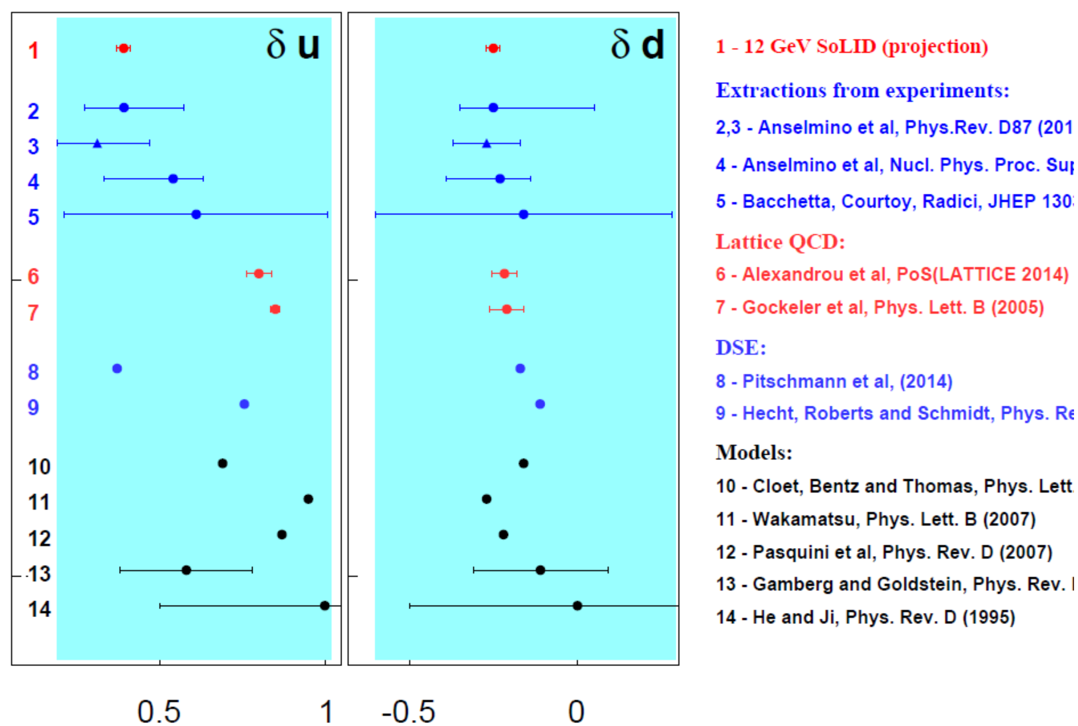
Collins Asymmetries



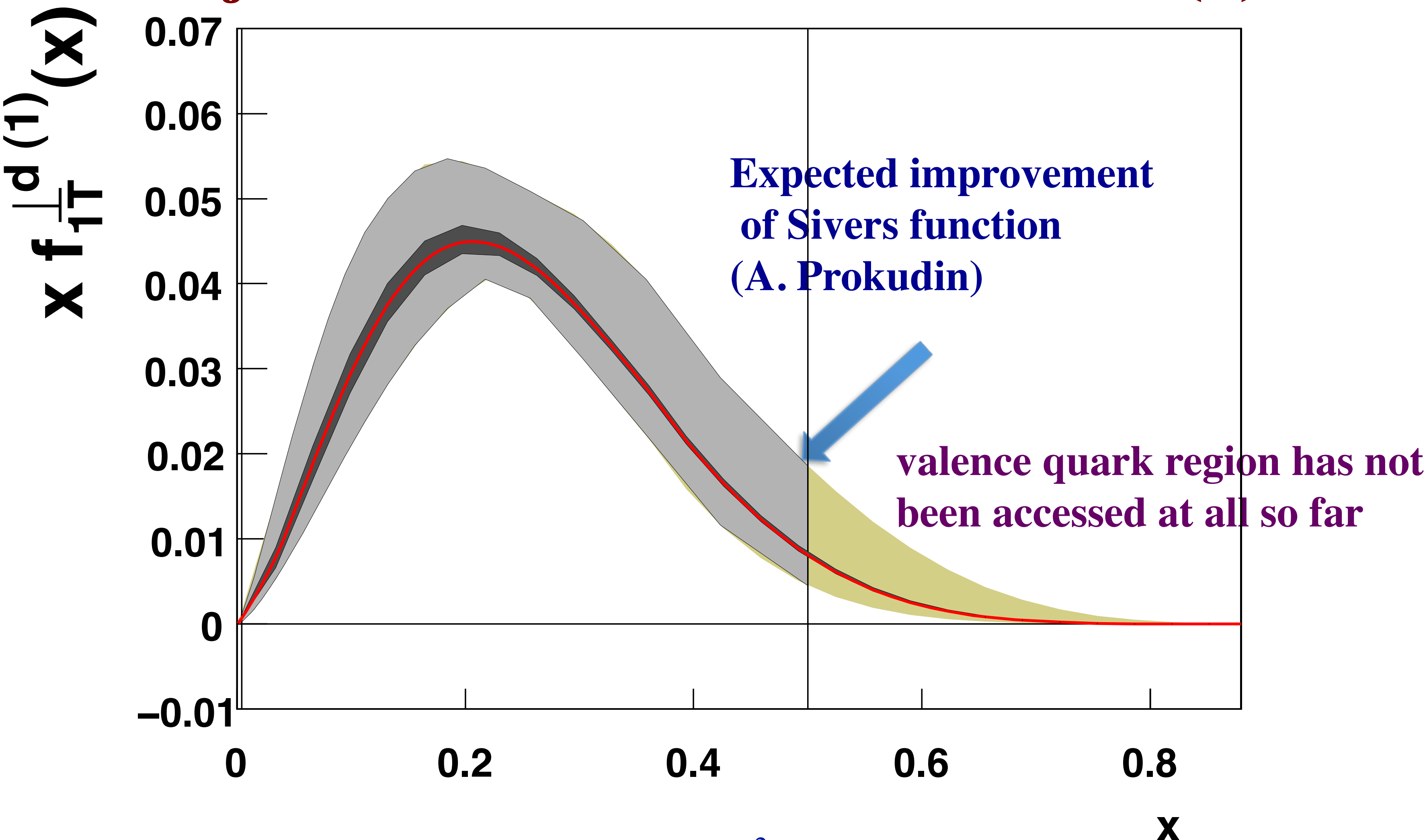
Total 1400 bins in x, Q^2, P_T and z for 11/8.8 GeV beam

X. Qian et al in PRL 107, 072003

Tensor Charges



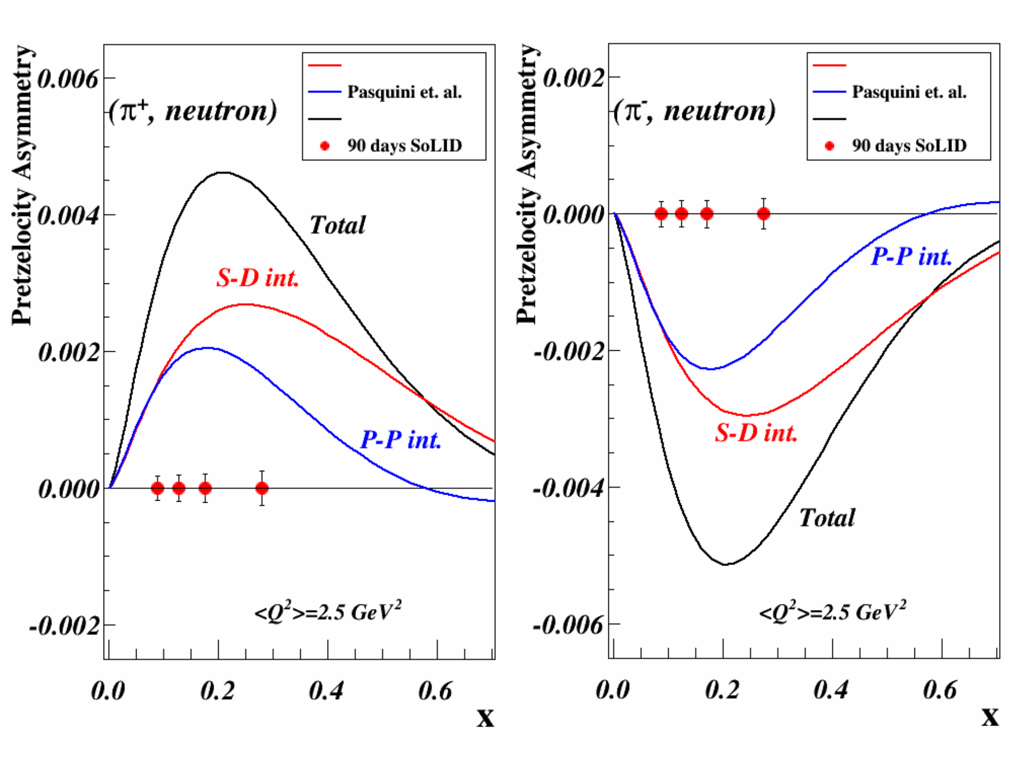
Projected measurements in 1-D (x)



Assumption: We know the k_T dependence, Q^2 evolution of TMDs.
Also knowledge on TMFF → project onto 1-D in x to illustrate the power of SoLID-^{3}He. **SoLID 4-D precision data will reduce model dependence**

TMDs: 3-d Structure, Quark Orbital Motion

- TMDs : Correlations of transverse motion with quark spin and orbital motion
- **Without OAM, off-diagonal TMDs=0,**
  no direct model-independent relation to the OAM in spin sum rule yet
- Sivers Function: QCD lensing effects
- In a large class of models, such as light-cone quark models
  Pretzelosity: DL=2 (L=0 and L=2 interference , L=1 and -1 interference)
  Worm-Gear: DL=1 (L=0 and L=1 interference)
- **SoLID with trans polarized n/p → quantitative knowledge of OAM (indirect)**



Other TMD programs at JLab

E12-09-018 at JLab Hall-A

Physics Goal: measure **transverse** target SSA (A_{UT}) in ^{3}**He**(**e**,e'h)X in the valence region

- SIDIS at 8.8 and 11 GeV, luminosity: 4.10^{36} cm^{-2} s^{-1}, 40 μA
- 3D binning: 6 ($0.1 < x < 0.7$) × 5 ($0.2 < z < 0.7$) × 6 ($0 < p_T$ (GeV) < 1.2)
- Typically 120 bins, dependence on Q2 gives fully-differential analysis

SoLID E12-10-006: 1400 bins, 4D-MAPPING.
$0.05 < x < 0.6$, $0.3 < z < 0.7$, $0 < p_T$ (GeV) $< \sim 1$, $1 < Q^2$ (GeV^2)<8 with $\Delta Q^2 = 2$ GeV^2

CLAS12 Program at 11GeV

Dual H and D target (if pol. 10^{35} cm^2 s^{-1} at 10 nA)

- E12-07-007: long. pol. **Measures $x(\Delta\bar{u}-\Delta\bar{d})$**
  unpol. for **multiplicity and strange PDF measurements**

- E12-08-008: unpol. **Measures A_{UU}**(cos 2ϕ of charged kaons))

- E12-09-009, long pol.
- E12-07-107, long. pol. **NH_3** target,

Measure A_{UL} and A_{LL}
(sin2ϕ of charged pions)

Programs complimentary to SoLID, but no competition for precision

Summary of SoLID SIDIS program

- SoLID: unique combination of large acceptance and high luminosity – truly utilize 12-GeV upgrade to its full potential, no competition for SIDIS physics
- SoLID SIDIS: comprehensive program with both proton and ``neutron" targets in the same setup allows for flavor separation with better control of systematics
- Multi-dimensional binning of the data with high precision help reduce theoretical uncertainties in extracting TMDs
- Apart from three approved experiments, two ``bonus" experiments will accumulate data without additional beam time, providing complementary way to access transversity, and new information, and expect more such bonus

Electroweak Interactions at scales much lower than the W/Z mass

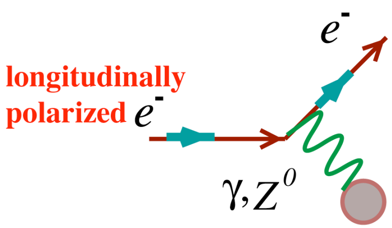
TeV-Scale Probe: Indirect Clues

NP: Fundamental Symmetries; HEP: The Intensity/Precision Frontier

Examples: Heavy Z's, light (dark) Z's, technicolor, compositeness, extra dimensions, new ideas???, …

How can the Standard Model, with all of its holes, predict precision measurements so well??

Parity-violating Electron Scattering



$$-A_{LR} = A_{PV} = \frac{\sigma_\uparrow - \sigma_\downarrow}{\sigma_\uparrow + \sigma_\downarrow} \sim \frac{A_{weak}}{A_\gamma} \sim \frac{G_F Q^2}{4\pi\alpha}\left(g_A^e g_V^T + g_V^e g_A^T\right)$$

g_V and g_A are function of $\sin^2\theta_W$

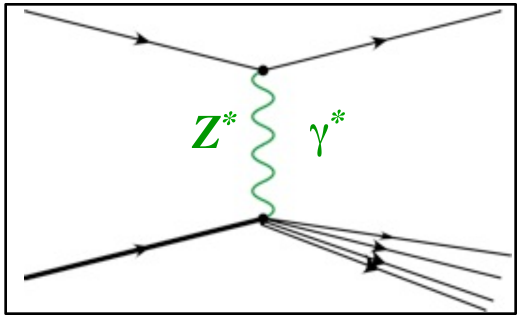
$A_{PV} \sim 10^{-5} \cdot Q^2$ **to** $10^{-4} \cdot Q^2$

Specific choices of kinematics and target nuclei probes different physics:

- *In mid 70s, goal was to show $\sin^2\theta_W$ was the same as in neutrino scattering*
- *Since early 90's: target couplings probe novel aspects of hadron structure (strange quark form factors, neutron RMS radius of nuclei)*
- *Future: precision measurements with carefully chosen kinematics can probe physics at the multi-TeV scale, and novel aspects of nucleon structure*

PV Deep Inelastic Scattering

off the simplest isoscalar nucleus and at high Bjorken x



$$A_{PV} = \frac{G_F Q^2}{2\sqrt{2}\pi\alpha}\left[g_A \frac{F_1^{\gamma Z}}{F_1^{\gamma}} + g_V \frac{f(y)}{2}\frac{F_3^{\gamma Z}}{F_1^{\gamma}}\right]$$

$Q^2 >> 1\ GeV^2\ ,\ W^2 >> 4\ GeV^2$

$$A_{PV} = \frac{G_F Q^2}{\sqrt{2}\pi\alpha}\left[a(x) + f(y)b(x)\right]$$

$x \equiv x_{Bjorken}$

$y \equiv 1 - E'/E$

$$Y = \frac{1-(1-y)^2}{1+(1-y)^2 - y^2\frac{R}{R+1}}$$

$$R(x,Q^2) = \sigma^l/\sigma^r \approx 0.2$$

$$A_{\rm iso} = \frac{\sigma^l - \sigma^r}{\sigma^l + \sigma^r} = -\left(\frac{3G_F Q^2}{\pi\alpha 2\sqrt{2}}\right)\frac{2C_{1u} - C_{1d}(1+R_s) + Y(2C_{2u} - C_{2d})R_v}{5+R_s}$$

At high x, A_{iso} becomes independent of pdfs, x & W, with well-defined SM prediction for Q^2 and y

$$R_s(x) = \frac{2S(x)}{U(x)+D(x)} \xrightarrow{\text{Large } x} 0$$

$$R_v(x) = \frac{u_v(x)+d_v(x)}{U(x)+D(x)} \xrightarrow{\text{Large } x} 1$$

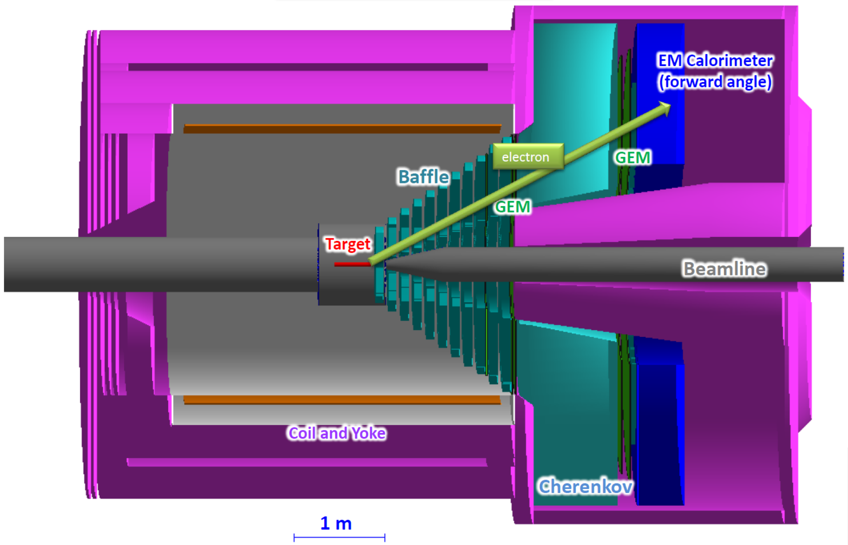
Interplay with QCD

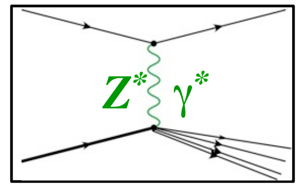
- Parton distributions (u, d, s, c)
- Charge Symmetry Violation (CSV)
- Higher Twist (HT)
- Nuclear Effects (EMC)

12 GeV Upgrade: Extraordinary opportunity to do the ultimate PVDIS Measurement

SOLID with the 12 GeV Upgrade

SoLID (PVDIS)



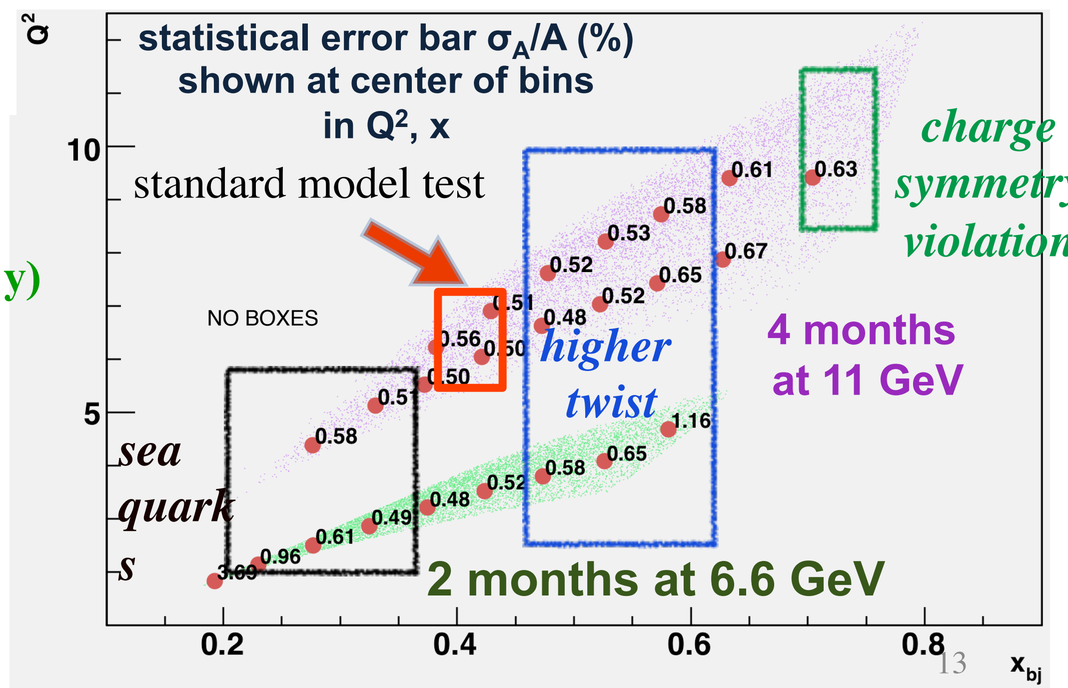


$$A_{PV} = \frac{G_F Q^2}{\sqrt{2}\pi\alpha}\left[a(x) + f(y)\boxed{b(x)}\right]$$

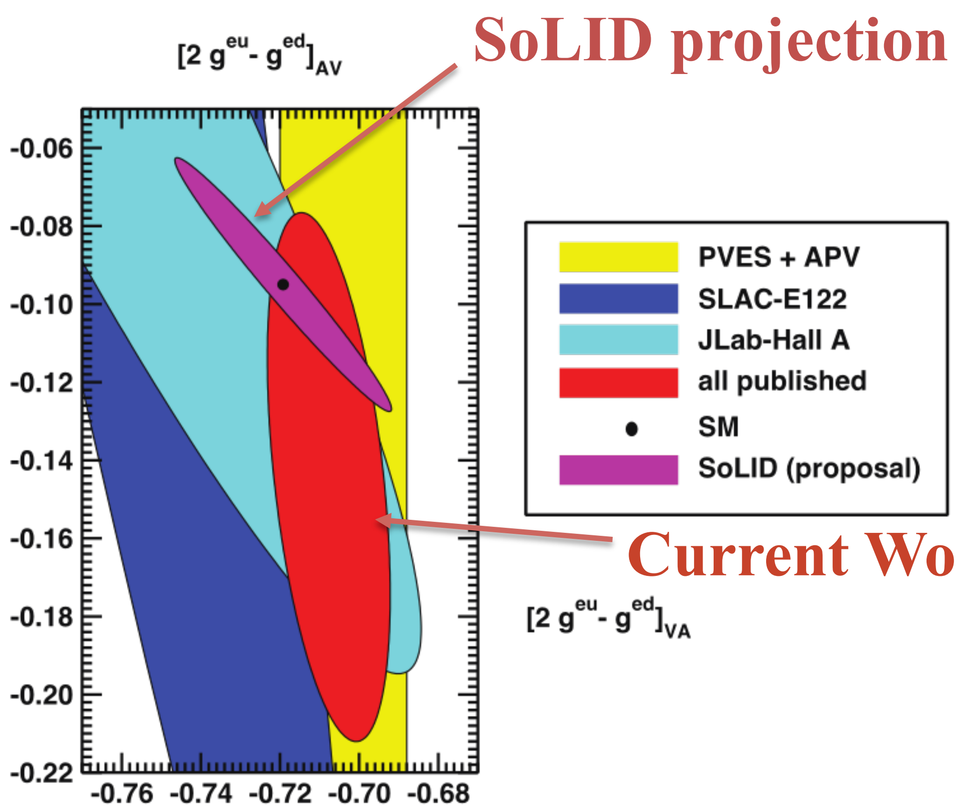
Strategy: sub-1% precision over broad kinematic range: **sensitive Standard Model test** *and* **detailed study of hadronic structure contributions**

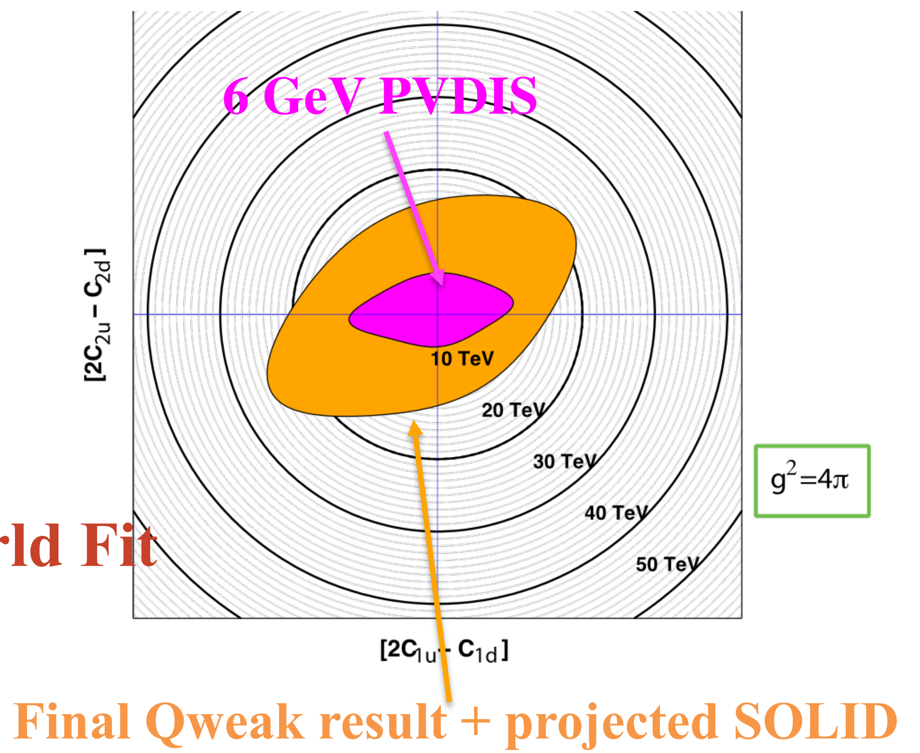
Requirements

- High Luminosity with E > 10 GeV
- Large scattering angles (for high x & y)
- Better than 1% errors for small bins
- x-range 0.25-0.75
- $W^2 > 4\ GeV^2$
- Q^2 range a factor of 2 for each x
  – (Except at very high x)
- Moderate running times



SOLID New Physics Sensitivity





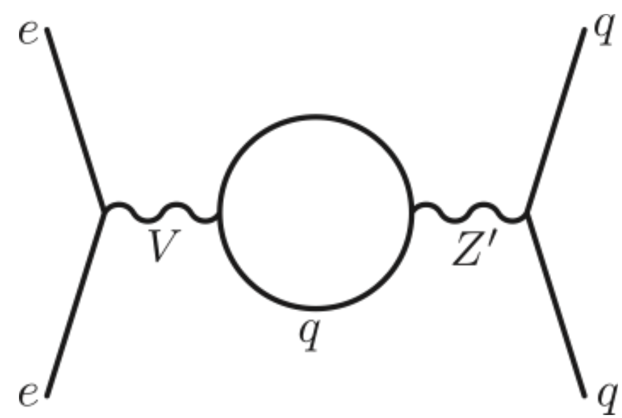
Qweak and SOLID will expand sensitivity that will match high luminosity LHC reach with complementary chiral and flavor combinations

Jlab 6-GeV PVDIS results
Wang *et al*., Nature 506, No. 7486, 67 (2014)

Unique SoLID Sensitivity

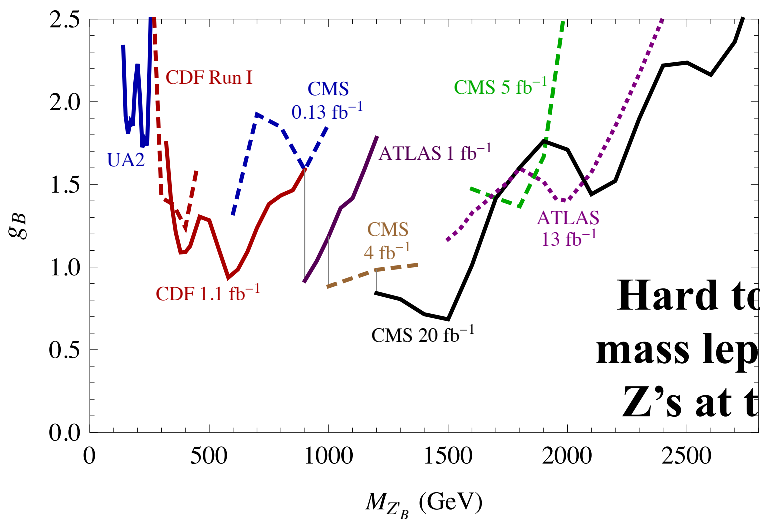
Leptophobic Z'

- *Virtually all GUT models predict new Z's*
- *LHC reach ~ 5 TeV, but....*
- *Little sensitivity if Z' doesnt couple to leptons*
- *Leptophobic Z' as light as 120 GeV might escape detection*
- *Leptophobic Z' might couple to dark matter*



arXiv:1203.1102v1

Buckley and Ramsey-Musolf



Hard to see low mass lepto-phobic Z's at the LHC

Since electron vertex must be vector, the Z' cannot couple to the C_{1q}'s if there is no electron coupling: can only affect C_{2q}'s

SOLID can improve sensitivity: 100-200 GeV range

15

Longstanding issue in proton structure

Proton PVDIS: d/u at high x

(high power liquid hydrogen target)

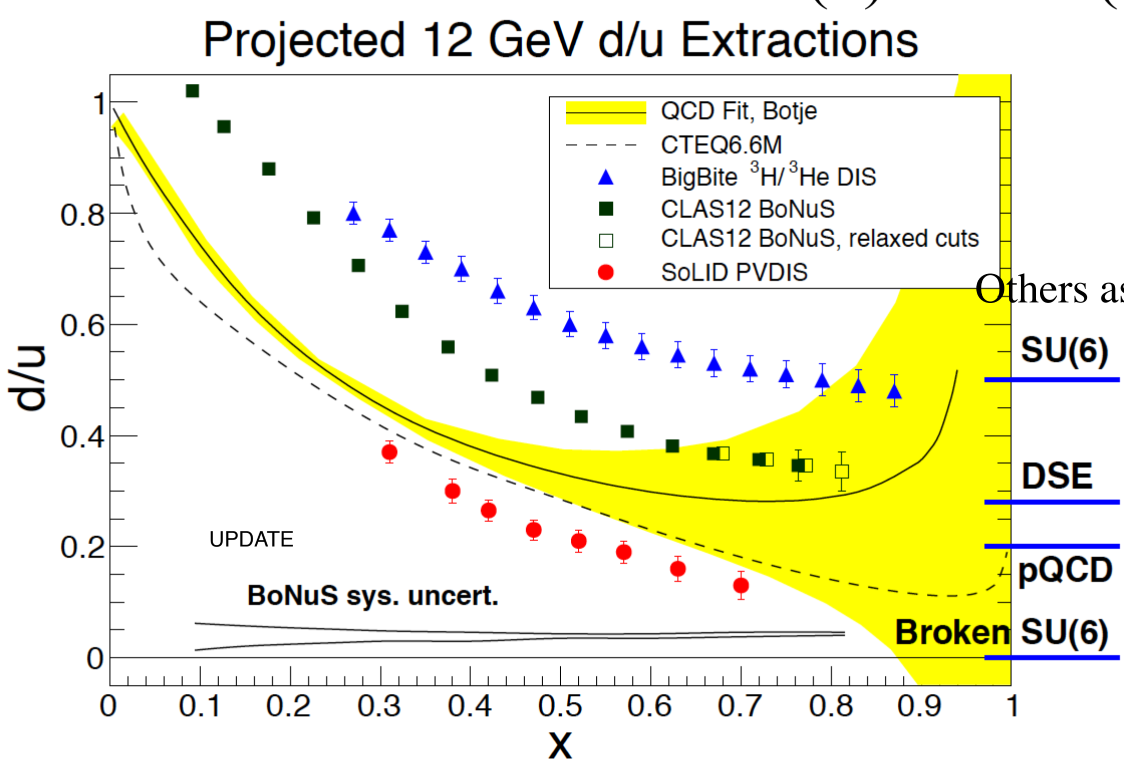
SU(6): d/u~1/2

Broken SU(6): d/u~0

Perturbative QCD: d/u~1/5

$$A_{PV} = \frac{G_F Q^2}{\sqrt{2}\pi\alpha}\left[a(x) + f(y)b(x)\right]$$

$$a^P(x) \approx \frac{u(x) + 0.91d(x)}{u(x) + 0.25d(x)}$$



Others assume CSV

- Three JLab 12 GeV experiments:
  - CLAS12 BoNuS - spectator tagging
  - BigBite - DIS $^3H/^3He$ Ratio
  - SoLID - PVDIS *ep*
- The SoLID extraction of *d*/*u* is made directly from *ep* DIS: *no nuclear corrections*

Summary of SoLID PVDIS program

- Parity-Violating Deep Inelastic Scattering with SoLID will allow a unique sensitivity to new physics in the 10-20 TeV region. A precursor of this experiment was recently highlighted in Nature.
- SoLID-PVDIS will significantly improve sensitivity to leptophobic Z' in 100-200 GeV region
- SoLID-PVDIS will enable the extraction of d/u directly from ep DIS, **no nuclear corrections**!
- SoLID-PVDIS has direct sensitivity to charge symmetry breaking effect at the partonic level – important for PDF and NuTev anomaly
- SoLID-PVDIS also has sensitivity to higher twist effect

J/ψ Opportunity at JLab 12GeV

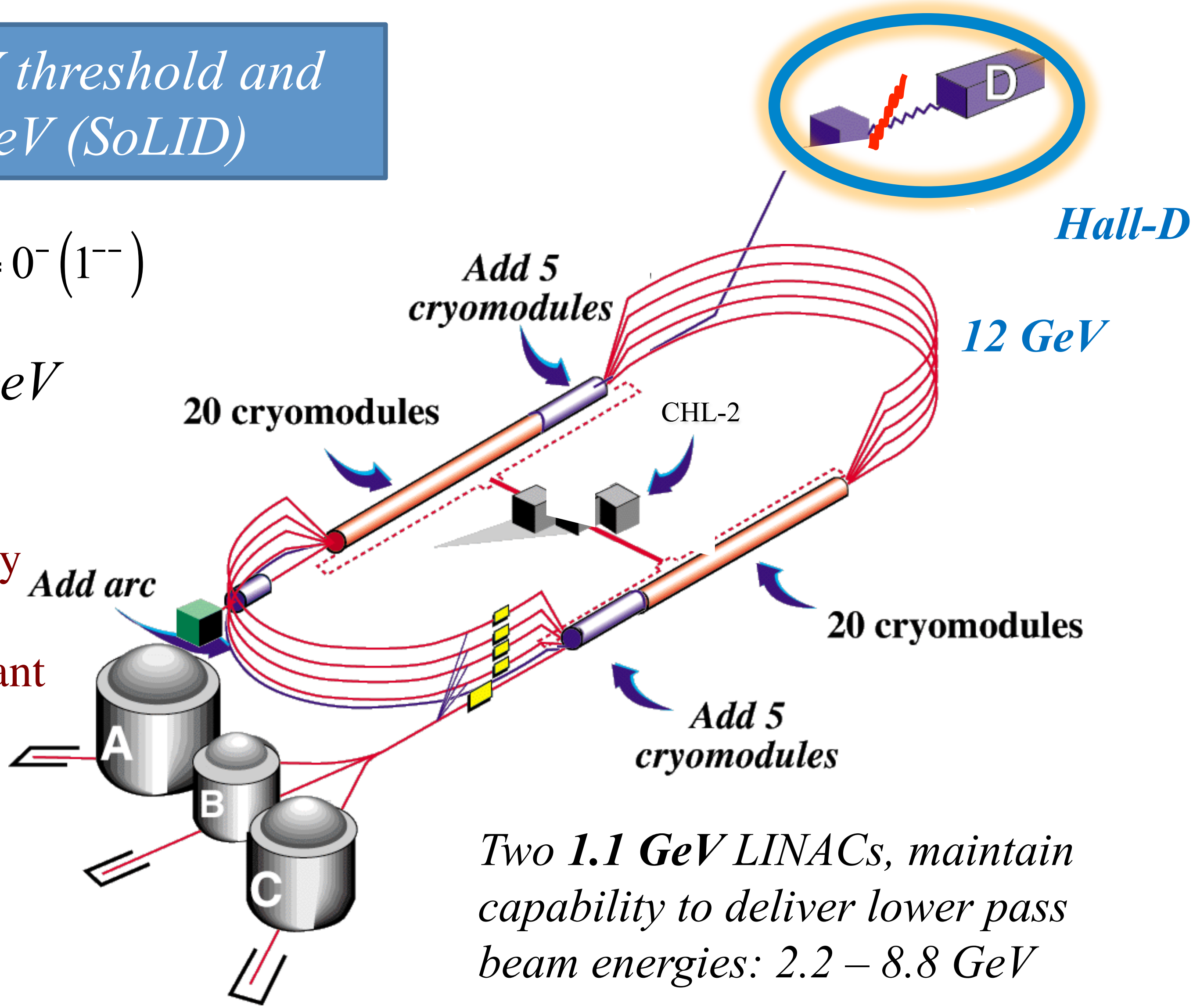
Cross 8.2 GeV threshold and reach 11GeV (SoLID)

$$J/\psi(1S): I^G\left(J^{PC}\right) = 0^-\left(1^{--}\right)$$

$$M_{J/\psi} \approx 3.097 GeV$$

Quark exchange interactions strongly suppressed, gluonic interactions dominant

J/ψ as probe of the strong color field in the nucleon



*Two **1.1 GeV** LINACs, maintain capability to deliver lower pass beam energies: 2.2 – 8.8 GeV*

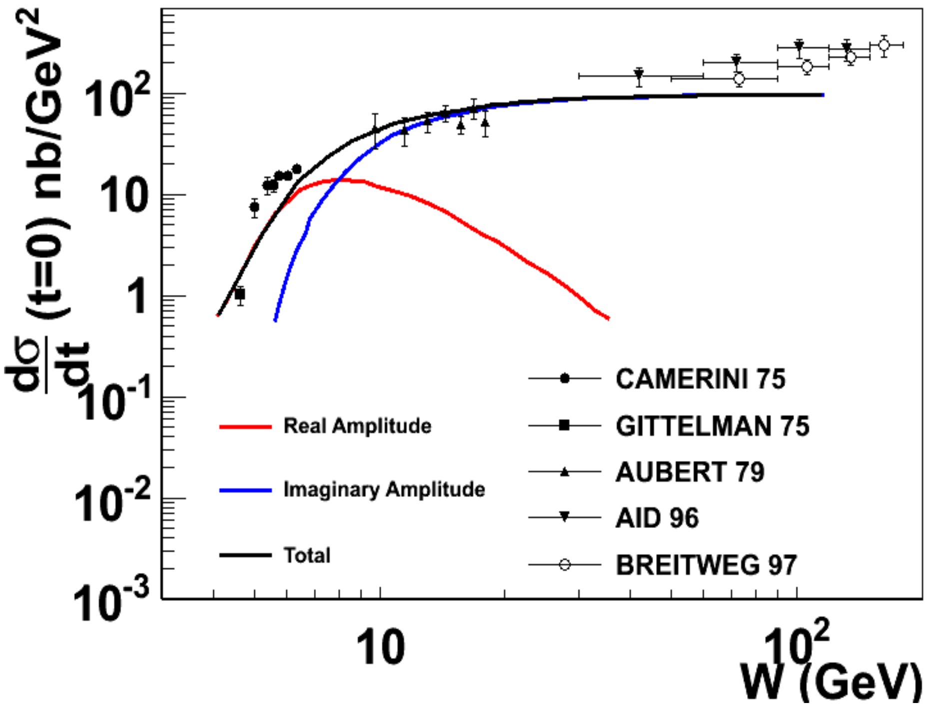
Photo- and Electro-production of J/ψ at JLab is an opportunity

Reaction Mechanism

$$\frac{d\sigma_{\gamma N\to\psi N}}{dt}(s,t=0) = \frac{3\Gamma(\psi\to e^+e^-)}{\alpha m_\psi}\left(\frac{k_{\psi N}}{k_{\gamma N}}\right)^2\frac{d\sigma_{\psi N\to\psi N}}{dt}(s,t=0)$$

$$\frac{d\sigma_{\psi N\to\psi N}}{dt}(s,t=0) = \frac{1}{64\pi}\frac{1}{m_\psi^2(\lambda^2-m_N^2)}|\mathcal{M}_{\psi N}(s,t=0)|^2$$

- **Imaginary part** is related to the total cross section through optical theorem
- **Real part contains the conformal (trace) anomaly**
  - Dominate the near threshold region

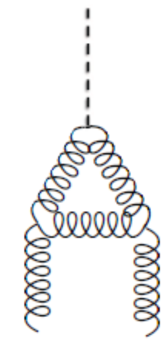


A measurement near threshold could shed light on the conformal anomaly

Conformal (Trace) Anomaly

- Connecting
  - **Trace of energy momentum tensor**
  - **"Beta" function** energy evolution of strong interaction coupling constant

$$\boxed{G^{\alpha\beta\gamma} G^{\gamma}_{\alpha\beta}}$$



$$\boxed{< N \,|\, \frac{\beta(g)}{2g} G^{\alpha\beta\gamma} G^{\gamma}_{\alpha\beta} + \sum_{u,d,s,} m_q \bar{q} q \,|\, N >= M_N}$$

Update needed

$$H_{QCD} = H_q + H_m + Hg + H_a$$

$H_q =$ Quark energy $\int d^3x\, \psi^\dagger \left(-i\mathbf{D}\cdot\alpha\right)\psi$

$H_m =$ Quark mass $\int d^3x\, \bar{\psi} m \psi$

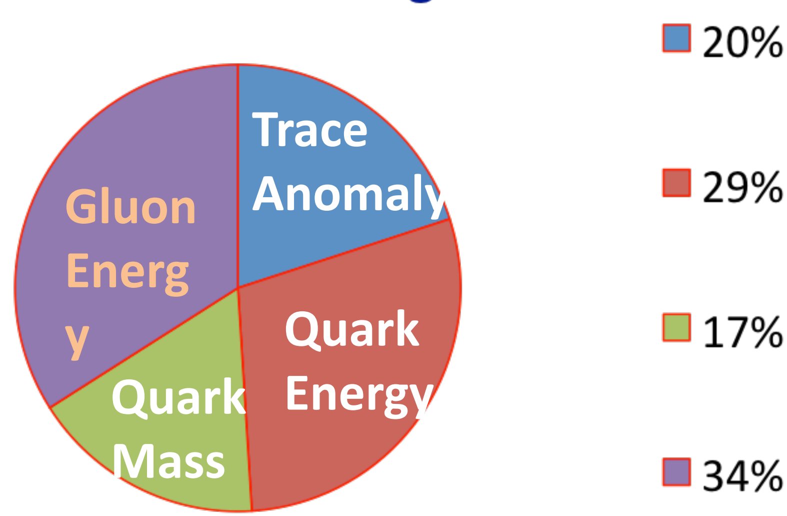
$H_g =$ Gluon energy $\int d^3x\, \frac{1}{2}\left(\mathbf{E}^2 + \mathbf{B}^2\right)$

$H_a =$ Trace anomaly $\int d^3x\, \frac{9\alpha_s}{16\pi}\left(\mathbf{E}^2 - \mathbf{B}^2\right)$

Sets the scale for the Hadron mass!

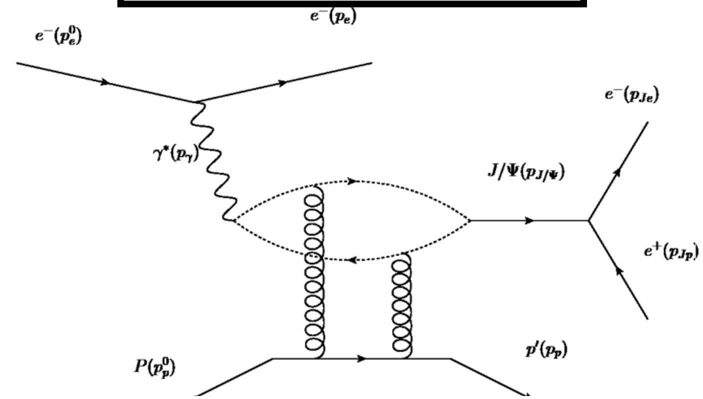
X. Ji PRL 74 1071 (1995)

Proton Mass Budget



J/ψ @ SoLID

$$\boxed{\gamma^* + N \rightarrow N + J/\psi}$$



- E12-12-006

Spokespersons:

Kawtar Hafidi (ANL),*Zein-Eddine Meziani* (Temple)

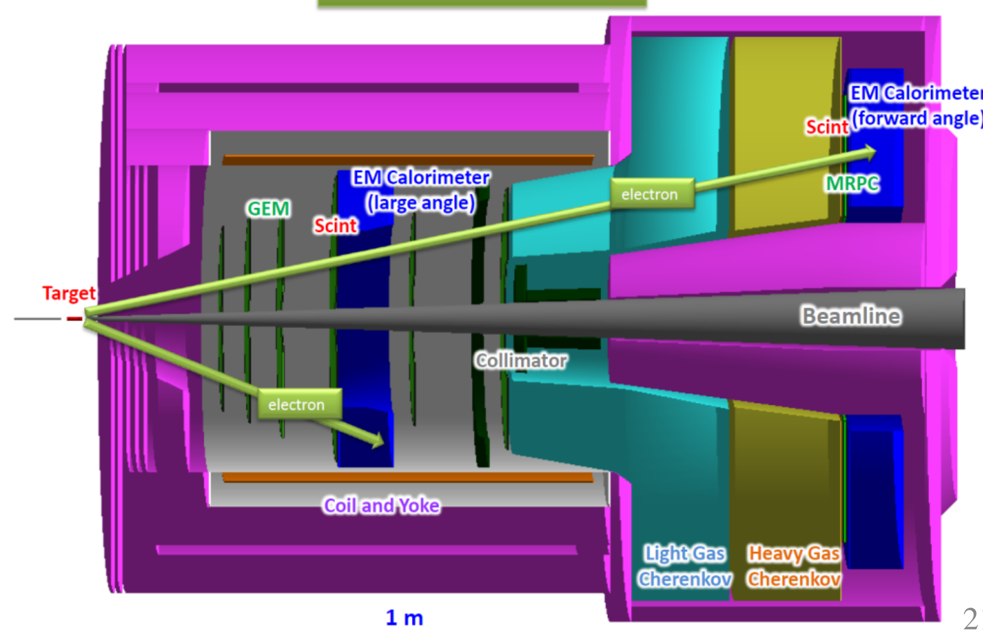
Xin Qian (BNL), *Nikos Sparveris* (Temple)

Zhiwen Zhao (Jlab/ODU)

$$e\ p \rightarrow e'\ p'\ J/\psi(e^-\ e^+)$$

$$\gamma\ p \rightarrow p'\ J/\psi(e^-\ e^+)$$

SoLID (J/ψ)



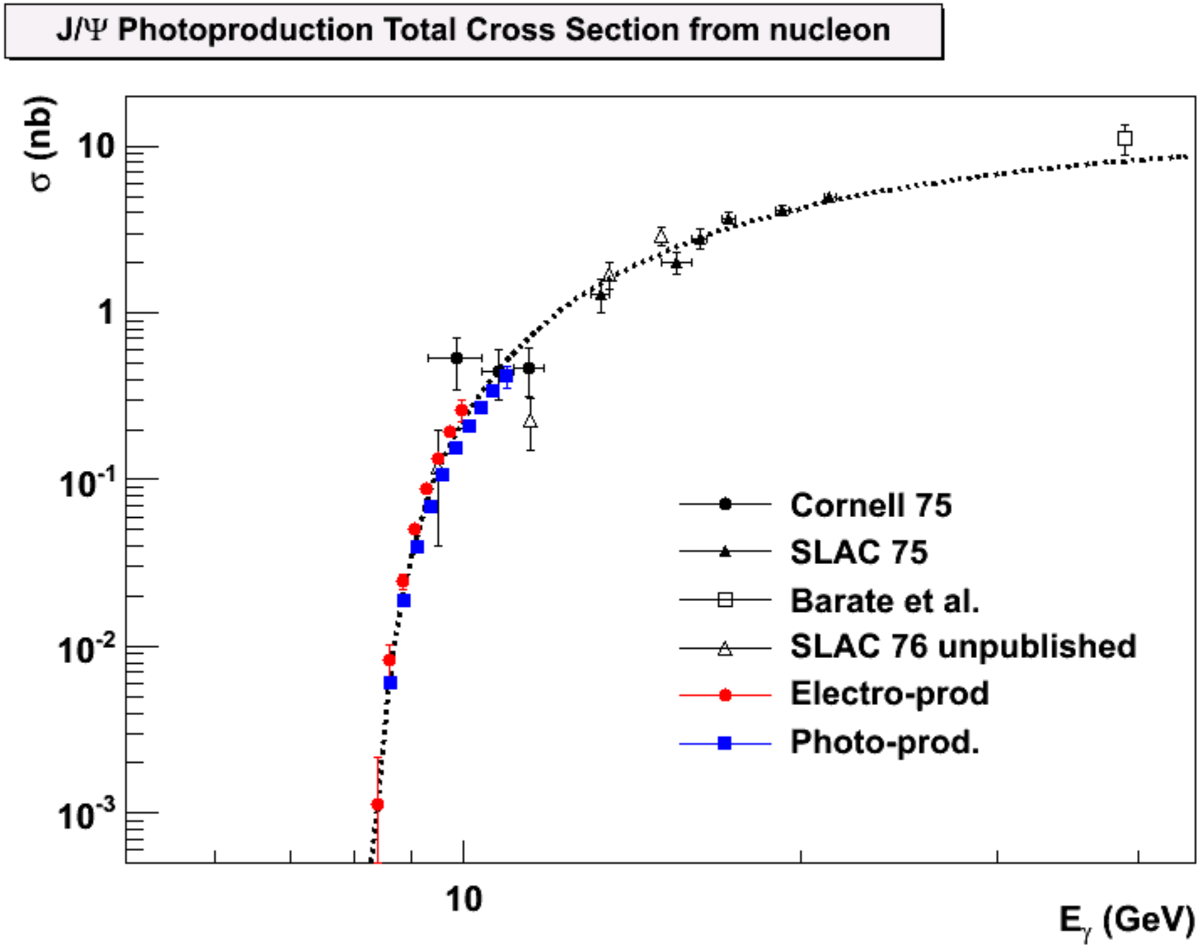
Electro-production

- Detect decay e⁻ e⁺ pair and scattered e⁻

Photo-production

- Detect decay e⁻ e⁺ pair and recoil p
- Trigger: detect decay pair only, good for both production

Projection of Total Cross Section



Lumi 1.2e37/cm^2/s
11GeV 3uA e- on 15cm LH2
50 Days

No competition in statistics

With < 0.02 GeV photon energy resolution and small binning to study the threshold behavior of cross section, ~10% stat and 15% sys uncertainties

Summary of SoLID J/Ψ program

- SoLID: unique combination of large acceptance and high luminosity –allow for complete kinematic determination for electro- and photo-production of J/Ψ with unprecedented precision in previously unexplored region near threshold
- Probe strong color force in nucleon
- Important for QCD conformal (trace) anomaly, origin of proton mass, and its mass budget
- Opens window for future studies of J/Ψ-nucleon interaction, search for exotic J/Ψ-nuclear bound state due to QCD van der Waals force, and more

Summary of SoLID Physics Overview

Full exploitation of JLab 12 GeV Upgrade

→ **SOLID:** A **Large Acceptance** Detector **THAT** Can Handle **High Luminosity** (10^{37}-10^{39})

Rich, vibrant and important physics program to address some of the most fundamental questions in Nuclear and Particle Physics

•Unprecedented precision in three-dimensional imaging of nucleon in momentum space, No competition in the proposed program on TMD

•PVDIS probing new physics in 10-20 TeV region complementary to LHC search, improving sensitivity to leptophobic Z' in 100-200 GeV;

- QCD bonus: sensitivity to charge symmetry violation and high-twist effects

• J/ψ production: unprecedented precision in a completely unexplored kinematic region near the threshold, probing strong color field in the nucleon, and QCD conformal anomaly, no competition

SoLID will provide the community with a general-purpose solenoidal detector capable to operate at high luminosities while still maintain large acceptance. Much more physics is foreseen with such a device, such as di-hadron detection, SSA measurements, and tagged DIS experiments, and much more!

Backup Slides

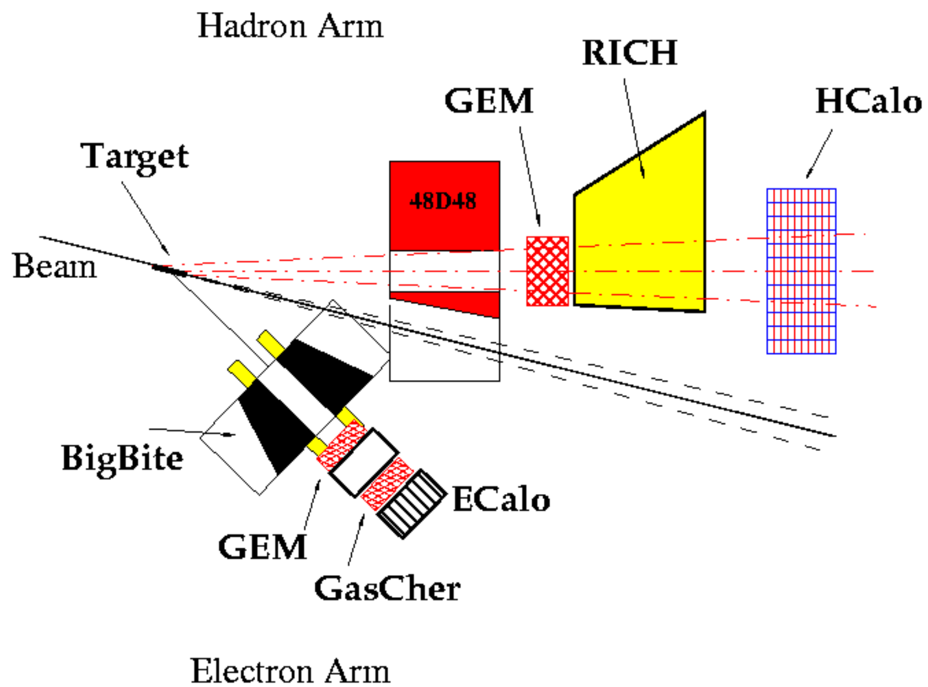
Experiment E12-09-018 at JLab Hall-A

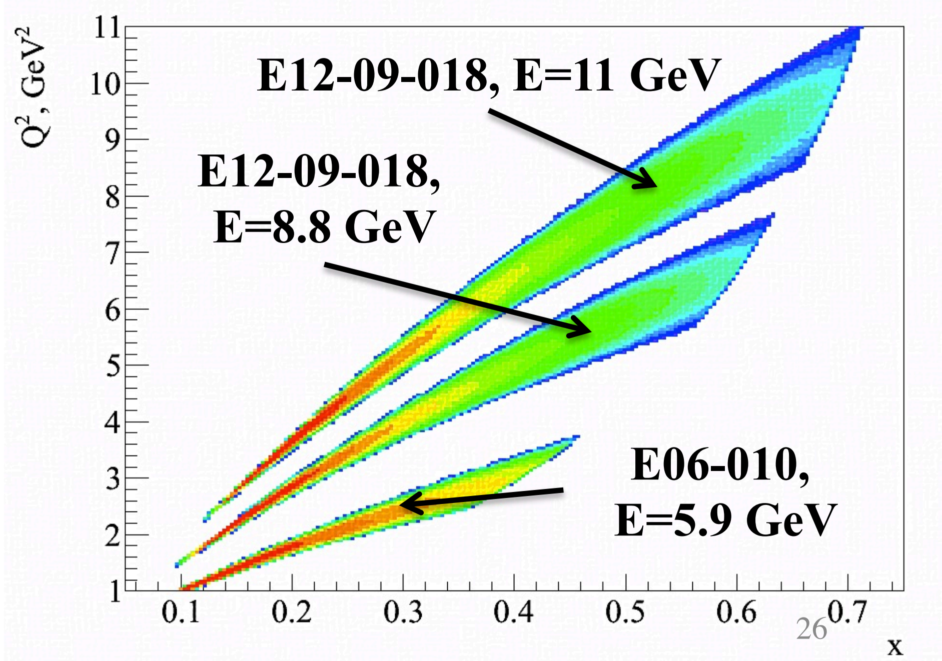
Physics Goal: measure **transverse** target SSA (A_{UT}) in ^{3}**He**(**e**,e'h)X in SIDIS kinematics in the valence region

Main experiment parameters:

- 2 beam energy settings: 8.8 and 11 GeV
- Electron-polarized neutron luminosity: 4.10^{36} cm^{-2} s^{-1}, 40 μA
- 3D binning: 6 ($0.1 < x < 0.7$) × 5 ($0.2 < z < 0.7$) × 6 ($0 < p_T$ (GeV) < 1.2)
- Typically 120 bins, dependence on Q2 gives fully-differential analysis

SoLID E12-10-006: 1400 bins, 4D-MAPPING.
$0.05 < x < 0.6$, $0.3 < z < 0.7$, $0 < p_T$ (GeV) $< \sim 1$, $1 < Q^2$ (GeV^2)< 8 with $\Delta Q^2 = 2$ GeV^2



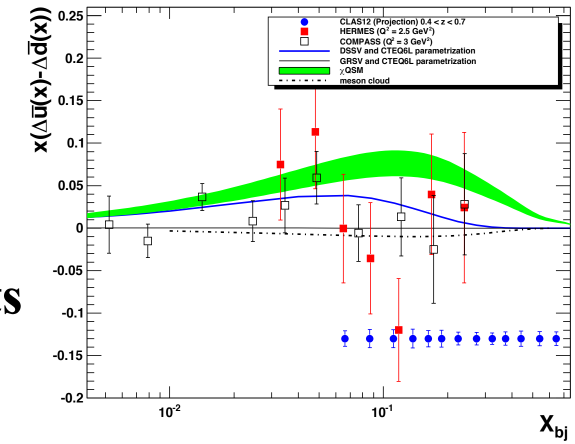


CLAS12 Program at 11GeV

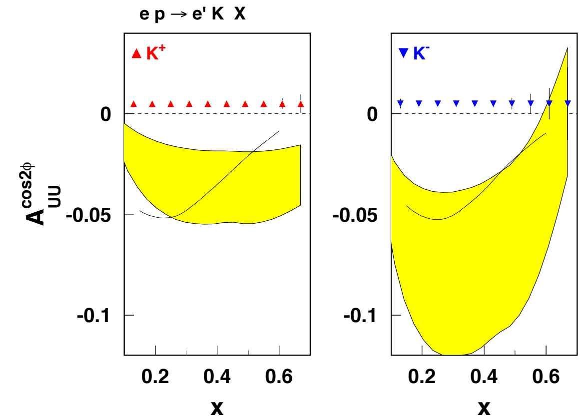
- E12-07-007, Dual H and D target:

  - long. pol. with 10^{35} cm^2 s^{-1} at 10 nA, $0.05<x<0.7$
  Measures $x(\Delta\bar{u}-\Delta\bar{d})$

  - unpol. for **multiplicity and strange PDF measurements**



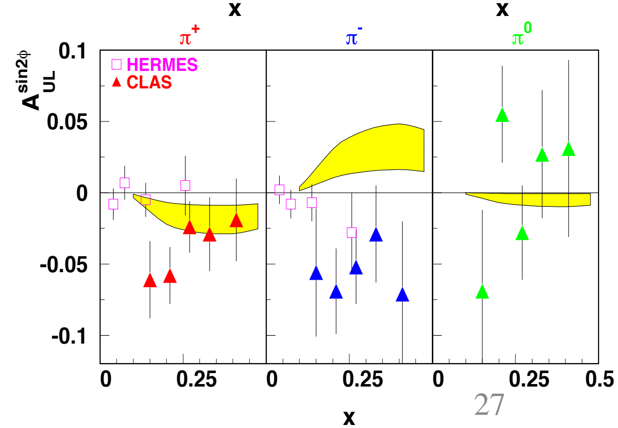
- E12-08-008
  - Dual unpol. H and D target
  $0.1<x<0.6$, $0<P_T$ (GeV)<1.2, $0.3<z<0.7$
  - **Measures A_{UU}**(cos 2ϕ of charged kaons))



- E12-09-009, Dual long pol. H and D target
$0.1<x<0.8$, $0<P_T$ (GeV)<1.2, $0.2<z<0.8$

- E12-07-107, long. pol. NH_3 target,

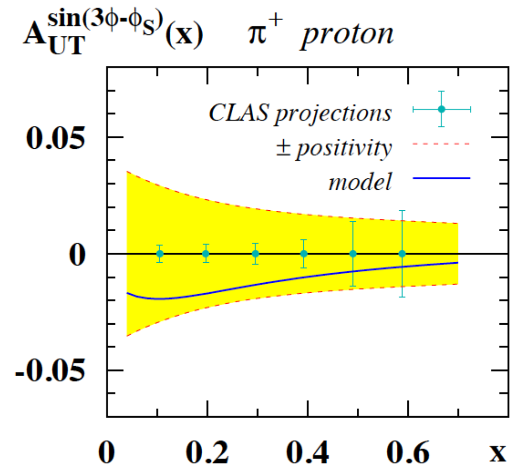
  - Both 10^{35} cm^2 s^{-1} at 10 nA
  - **Measure A_{UL} and A_{LL}** (sin2ϕ of charged pions)



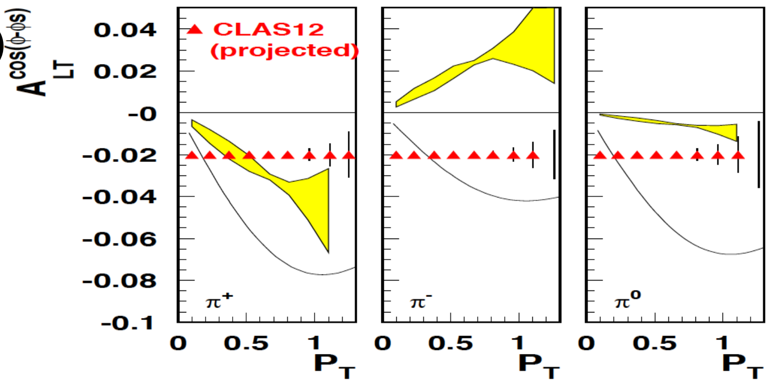
Program complimentary with SoLID

CLAS12 Program at 11GeV

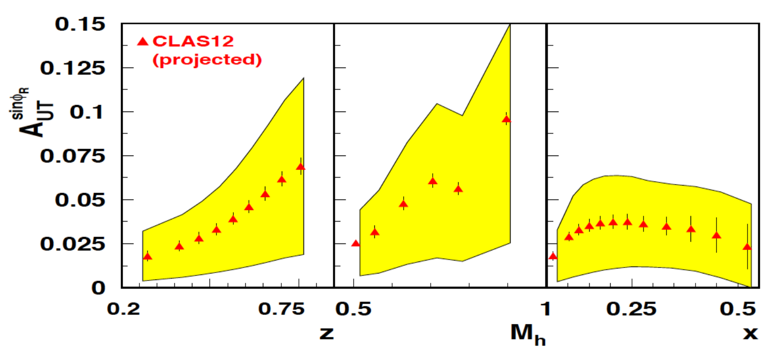
- C12-11-11: ep↑-> ehX
  - HD-ice transversely pol. Target, 10^{34} cm^2 s^{-1}
    $0.1<x<0.6$, $0<P_T$ (GeV)<1.5, $0.3<z<0.7$
  - **Measures A_{UT}** (access to the SSA: transversity, **Sivers** and "pretzelosity" functions)



  - **Measures A_{LT}** (access to the DSA: worm gear)



- C12-12-009: ep↑-> e$\pi^+\pi^-$X
  - HD-ice transversely pol. Target, 10^{34} cm^2 s^{-1}
    $0.1<x<0.6$, $0<P_T$ (GeV)<1.5, $0.3<z<0.7$
  - **Measures A_{UT}** (access to the SSA: transversity)



Program complimentary with SoLID

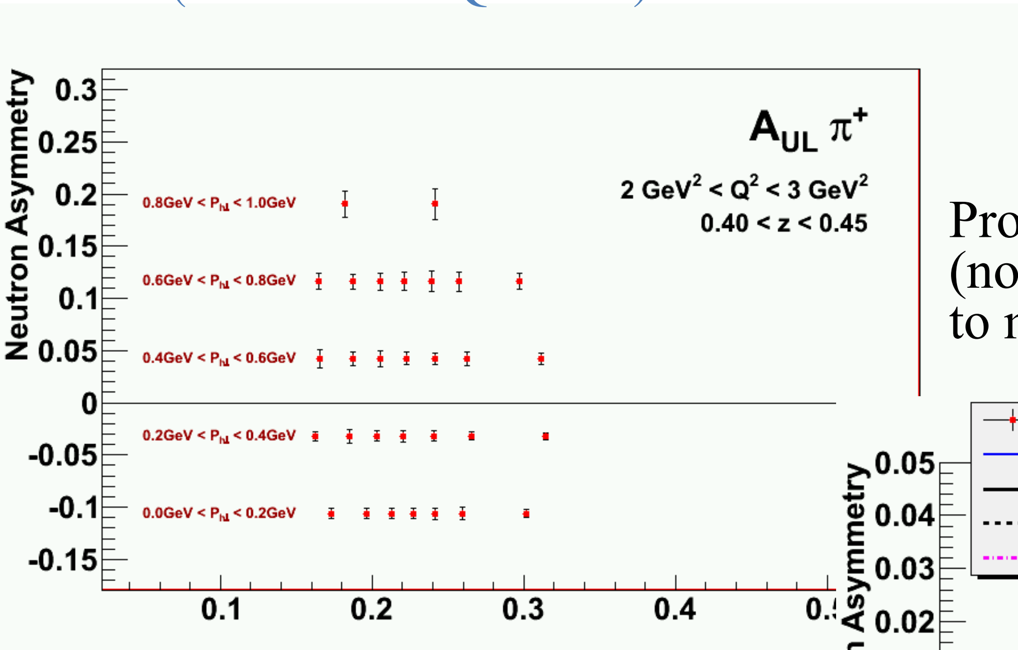
J/ψ @ JLab

- SoLID (E12-12-006)
  - 1e37/cm^2/s Luminosity, 3uA 11Gev e$^-$ beam on LH2 for 50 days
  - Uniquely combine large acceptance and high luminosity
- CLAS12 (E12-12-001)
  - together with TCS
  - 1e35 /cm^2/s Luminosity, 11Gev e$^-$ beam on LH2 for 120 days
  - much lower statistics than SoLID
- Hall D
  - No approved experiment
  - photon beam only, low luminosity
  - barrel calorimeter is not optimized for high energy e$^-$/e$^+$ detection
- Other halls
  - No approved experiment
  - Detection acceptance is limited

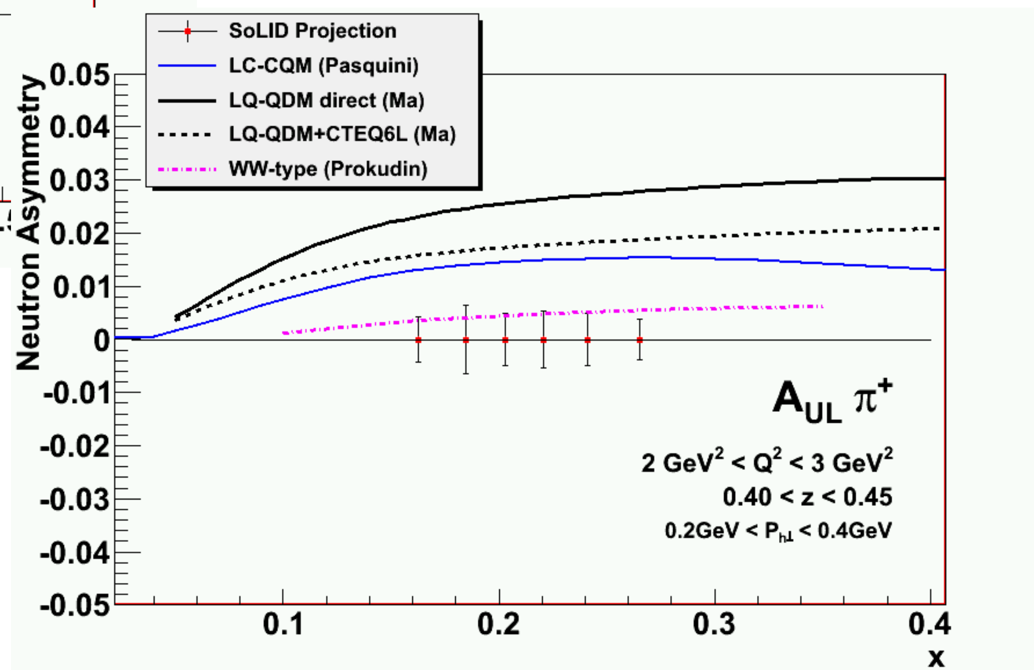
SoLID E12-11-007 Projection/A_{UL} (Partial)

- Projection of a single Q^2-z bin for π^+

(one out of 48 Q^2-z bins)

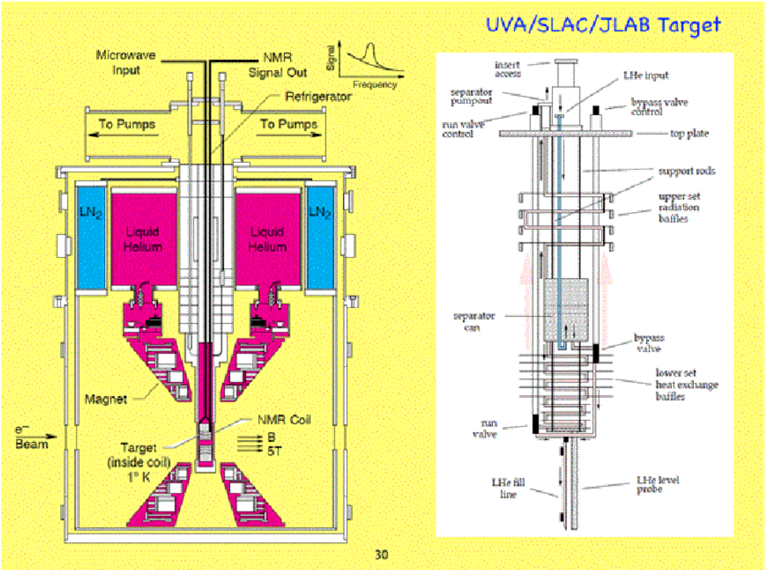


Projection of a single Q^2-z-PT bin for π^+ (no existing measurement) and compared to model predictions for SoLID kinematics

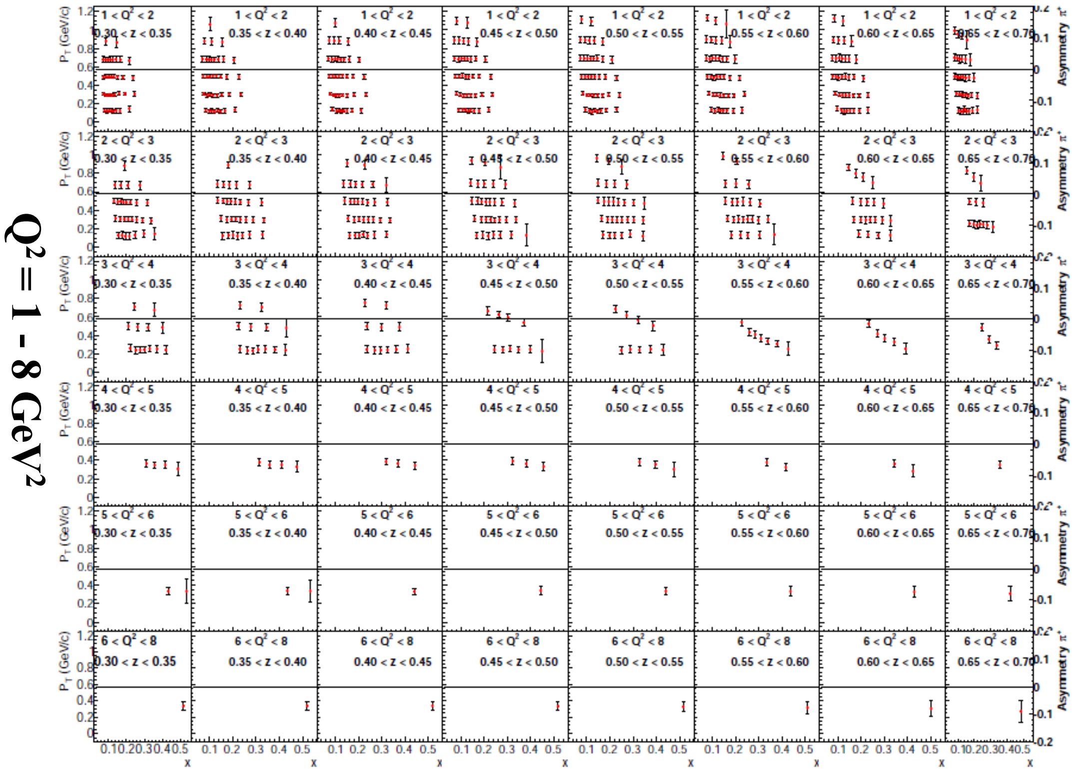


Experiment E12-11-108

Target Single Spin Asymmetry in SIDIS *(e, eπ$^{\pm}$)* Reaction on a Transversely Polarized Proton Target and SoLID



- Use similar detector setup as that of two approved ^{3}He SoLID expts.
- Use JLab/UVa polarized NH_3 target with upgraded design of the magnet
- Target spin-flip every two hours with average in-beam polarization of 70%
- Polarized luminosity with 100nA current: 10^{35} cm^{-2}s^{-1}
- Beamline chicane to transport beam through 5T target magnetic field (already used for g2p expt.)

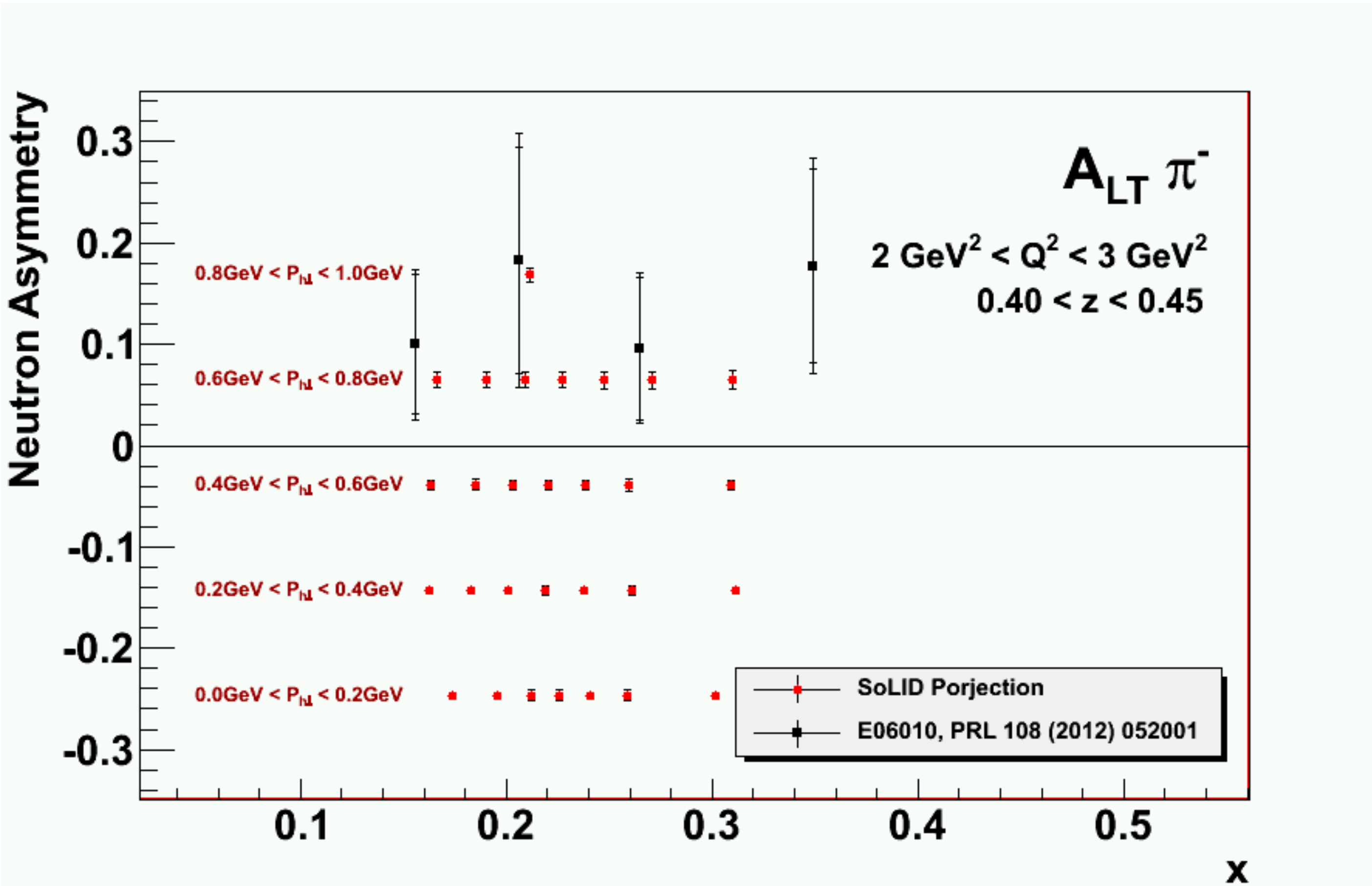


Z = 0.3 – 0.7

Spokespersons:
K. Allada (Jlab), J. P. Chen (Jlab), Haiyan Gao (Contact), Xiaomei Li (CIAE), Z-E. Meziani (Temple)

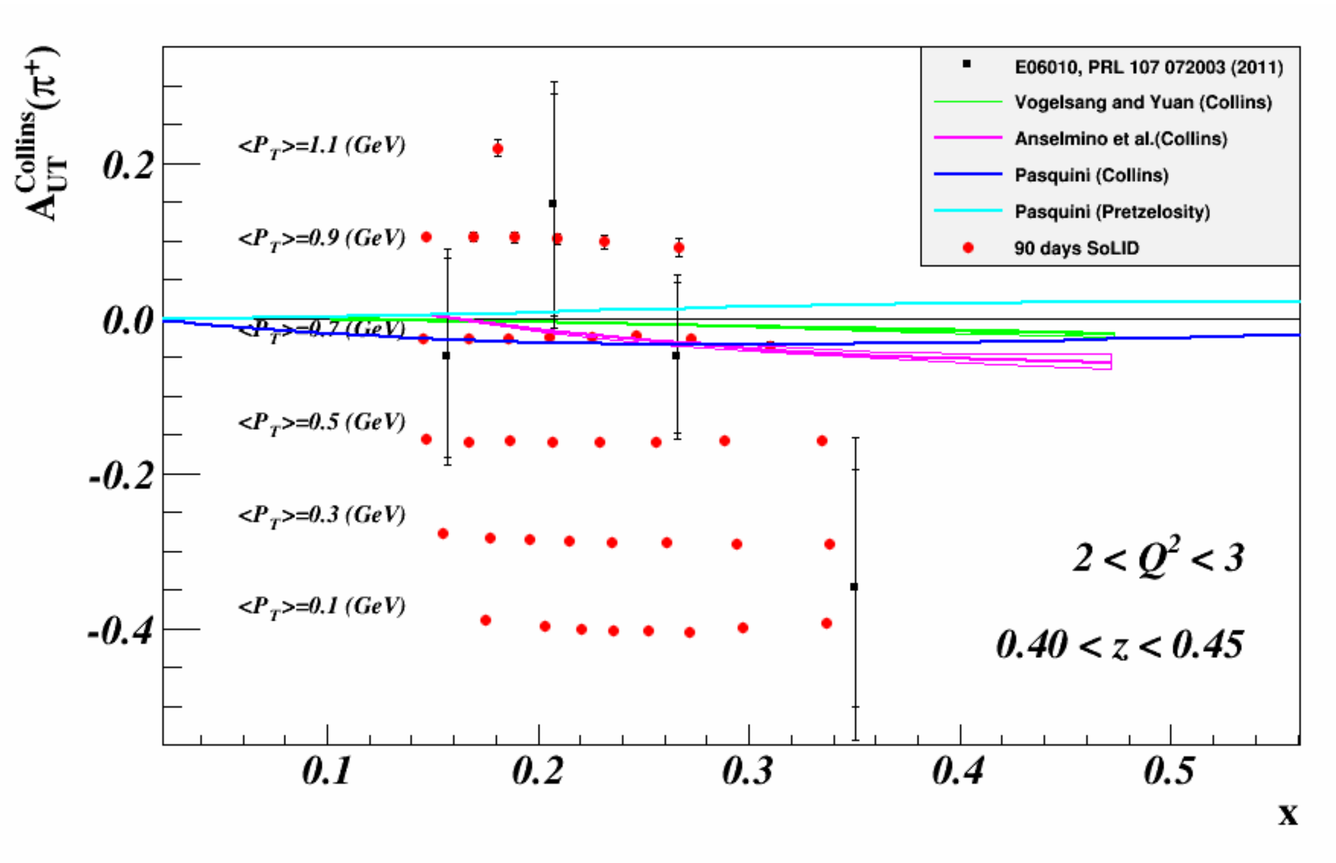
SoLID E12-11-007 Projection for A_{LT} (Partial)

- E12-11-007 and E12-10-006:
  Neutron A_{LT} Projection of one out of 48 Q^2-z bins for π^-



E12-11-007 spokespersons: J.P. Chen, J. Huang, Yi Qiang, W.B. Yan (USTC)
E06010 Results, J. Huang et al., PRL108, 052001 (2012)

Projected Data (E12-10-006)



- Total 1400 bins in x, Q^2, P_T and z for 11/8.8 GeV beam.
- z ranges from 0.3 ~ 0.7, only one z and Q^2 bin of 11/8.8 GeV is shown here.

  π^+ projections are shown, similar to the π^- .

E12-10-006 Spokespersons: Chen, Gao (contact), Jiang, Qian and Peng

X. Qian et al in PRL 107, 072003

Charge Symmetry Violation

We already know CSV exists:

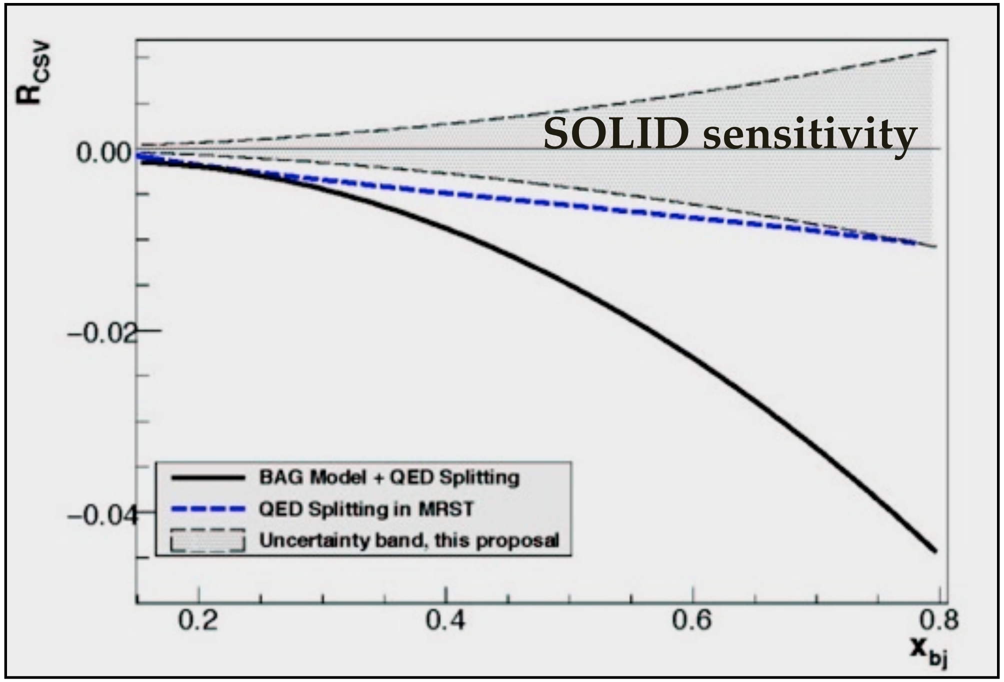
- u-d mass difference $\delta m = m_d - m_u \approx 4$ MeV
  $\delta M = M_n - M_p \approx 1.3$ MeV
- electromagnetic effects

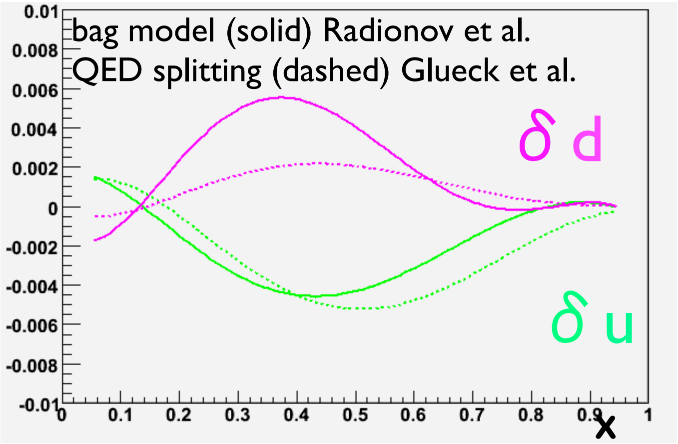
$$u^p(x) \stackrel{?}{=} d^n(x) \quad \Rightarrow \quad \delta u(x) \equiv u^p(x) - d^n(x)$$
$$d^p(x) \stackrel{?}{=} u^n(x) \quad \Rightarrow \quad \delta d(x) \equiv d^p(x) - u^n(x)$$

- Direct sensitivity to parton-level CSV
- Important implications for PDF's, eg. d/u
- Explanation of the NuTeV anomaly?

$$R_{CSV} = \frac{\delta A_{PV}}{A_{PV}} \approx 0.28 \frac{\delta u(x) - \delta d(x)}{u(x) + d(x)}$$

For A_{PV} in electron-^{2}H DIS





Coherent Program of PVDIS Study

Strategy: requires precise kinematics and broad range

Kinematic dependence of physics topics

	x	Y	Q^2
New Physics	none	yes	small
CSV	yes	small	small
Higher Twist	large?	no	large

- Measure A_d in **narrow** bins of x, Q^2 with 0.5% precision
- Cover broad Q^2 range for x in $[0.3,0.6]$ to constrain HT
- Search for CSV with x dependence of A_d at high x
- Use $x > 0.4$, high Q^2 to measure a combination of the C_{iq}'s

Fit data to:

$$A_{\mathrm{Meas.}} = A_{\mathrm{SM}}\left[1 + \frac{\beta_{\mathrm{HT}}}{(1-x)^3 Q^2} + \beta_{\mathrm{CSV}} x^2\right]$$